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Principles and applications of Piezoresponse Force Microscopy

A.L. Kholkin[1,2]

[1]*Department of Physics & CICECO-Aveiro Institute of Materials, University of Aveiro, 3810-193 Aveiro, Portugal*

[2]*School of Natural Sciences and Mathematics, Ural Federal University, 620000 Ekaterinburg, Russia*
e-mail: kholkin@urfu.ru

Over the last several years the field of ferroelectric and multiferroic oxides has been experiencing a significant revival. A clear manifestation of this trend is the publication of the new developments in this field in the Science and Nature magazines, as well as in numerous reviews. This is partly due to recent experimental achievements allowing synthesis of complex oxides and composites with atomic scale precision. As the quality of ferroelectric and multiferroic structures has proven to be essential to their functionality, a necessity to characterize their properties down to the nano- and even atomic scale lead to the wide application of electron and scanning probe microscopy (SPM) methods in this field. Specifically, Piezoresponse Force Microscopy (PFM) proved to be an indispensable tool for high-resolution characterization of ferroelectrics [1-3]. Versatility of PFM, which allows measurements of electronic behavior along with the nanoscale polarization control, makes it a method of choice for addressing the problems relevant to the scaling behavior of ferroelectrics. The standard implementation of this technique where an electrically biased probe scans the sample surface to modify or visualize the domain structure has been around for almost 20 years. However, recent years witnessed development of advanced modes of PFM such as resonance-enhanced PFM, Band Excittion PFM, switching spectroscopy PFM and so on.

This tutorial will briefly cover the physical, instrumental and interpretation aspects of a conventional PFM technique before focusing on application of advanced PFM modes to investigation of the dynamic switching and electronic properties of ferroelectric and piezoelectric nanostructures.

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